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ABSTRACT

In Rumania, the implementation of computers in social-economic life is being carried out with a view to creating a national data processing system. Parallel to the construction of electronic data processing equipment, there is a sustained concern for the selection and training of computer specialists. This study examined a psychological testing selection methodology for intensive courses for analyst programmers, junior programmers, card-punch operators, and computer operators. A psychological test battery was selected for each group, based on a job analysis of each occupation. Factor analyses and correlations between test performance and occupational success were used to investigate the validity of the test batteries. An optimum psychological selection strategy of the data processing personnel was worked out. This strategy reveals the necessity of complex psychological approaches in which selection is but one stage, a subroutine of the whole employment procedure and efficient socio-professional integration of an individual. (Author/BW)

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PSYCHOLOGICAL SELECTION OF PERSONNEL FOR DATA PROCESSING PROFESSIONS

by

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PSYCHOLOGICAL SELECTION OF PERSONNEL FOR DATA PROCESSING PROFESSIONS

Horia Pitariu

In Romania, the implementation of computers in social-economic life is carried out decidedly, according to a programme in stages, with a view to creating a national data processing system. Parallel to the construction of electronic data processing equipment, there is a sustained concern for the selection and training of specialists.

The great inflow of candidates of various professions for post-graduate, high-school graduate and on the job training for analyst-programmers, assistant-programmers, card-punch or computer operators, has imposed psychologic[illegible] examination/selection as a unique means of admission to courses.

This study has had its objective in experimenting a psychological selection methodology for intensive courses for analyst-programmers, junior-programmers, card-punch and computer operators (for card-punch operators [illegible] experimented a quick methodology for training).

PSYCHOLOGICAL SELECTION OF ANALYST-PROGRAMMERS AND JUNIOR-PROGRAMMERS

Psychological studies of the analysis and programming activity have been made on different occasions by authors from various countries (Hoc, 1974-1975; McNamara and Hughes, 1961; Moulin, 1971; Strizenec, 1973; Szafraniec, 1975). In short, the analyst is a person who formulates the problem - sometimes very spontaneously and informally -, interprets the information presented as data, gives it a form and assigns it a processing method. He has good knowledge of data processing, but he also possesses many general information and may be specialized in a particular field of application (Arsac, 1970). Programming is restricted to the activity of elaborating programmers as economically as possible and fixing of the line of conduct for the computer. The novelty of approaches and solutions is, by and large, specific to the analyst-programmer's work, as well as the absence of a standardized work scheme. The investigation into the psychical peculiarities that make up the personality of analysts and programmers has pointed to the existence of relatively similar profiles with some distinctions as regards the level and a few additional elements relating to the personality of the analyst, which seems to be more complex, since the field of preocupations is varied. In so far as we are concerned, the analyst-

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programmers have been treated differently from junior-programmers. The list below is a condensed presentation of the job requirements we have obtained.

Analyst-programmer	
Activity-type	**Professional knowledge/ psychic traits**
1. Working out the opportunity study and frame project.	Knowledge: industrial economy, work and production organization, management of industrial units, economic cybernetics, higher mathematics, production technology. Abilities: capacity for critical analysis and orientation in a new situation, facility in written and oral communication, heuristic thinking, flexibility, intuition, imagination, sociability, tact, dilligence, authority.
2. Working out of detail project, treatment organization, working out of the operation file and programming.	Knowledge: principles and techniques of studying the work process, methods of planning data processing systems, methods of statistical cybernetic analysis, programming languages, logical schemes, decision theory. Abilities: mathematical, readiness of thinking, logical reasoning, creativity, quick decision-making capacity for work planning and organization, easy adaptability to new situations, verbal fluency and accuracy, quick perception of form and space, authority, persuasiveness, caution, methodical spirit, concentration and lasting deliberated effort, capacity for team work.
3. Launching the system, its exploitation, preservation and improvement.	Knowledge: knowledge of the computer exploitation system - limits and possibilities, software and improvement. Abilities: receptivity to the new, pedagogical tactfulness, perseverance, accuracy in actions, capacity for goal attainment, correctness, discernments, ambition, tenacity.
JUNIOR-PROGRAMMER	
1. Problem analysis and choice of programming language.	Knowledge: elementary notions of industrial economy, principles of statistics, higher mathematics. Abilities: receptivity to verbal and written instructions, capacity of extracting the essence from a situation description, capacity of analysis and synthesis, capacity of cooperation with the colleagues, intuition.
2. Drawing up the logical scheme, writting the programme and its testing.	Knowledge: two or three programming languages, numbering systems, logical schemes, operating the card-punch and the computer. Abilities: fine capacity for analysis, imagination, creativity, form and space perception, numerical abilities, logical

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	thinking, good memory, capacity for concentration and long intelectual effort, concentrated and distributive attention, accuracy, moderate anxiety, tenacity and perseverance, patience, ambition, self-mobilization, intellectual dynamism, discipline, selfcontrol.
3.Programme exploitation, preservation and development/improvement.	Knowledge: knowledge of the computer exploitation, system-limits and possibilities, the management system of the data sets. Abilities: spontaneity, general intelligence, critical thinking, receptivity to novelty, capacity of synthesis, intellectual dynamism, capacity of work organization and planning, independence in actions, common sense.

Structure of the subjects sample. The research was carried out on a sample of 224 subjects, participants in post-graduate data processing courses: 28% economists, 36% engineers and 37% teachers (physicists and mathematicians). A rather varied group as to speciality were the engineers, since each industrial unit meant to form its own specialists, that is people who have a good knowledge of problems specific to the unit in question, which is very important for the analyst/analysis job. The average age of the participants was 28.7 years $\pm$ 4.8. Seniority ranged from 1 to 15 years.

The set of participants in the courses for the junior-programmer job consisted of 69 subjects, their average age being 28 years $\pm$ 6.7.

Job performance ratings. Without sticking to one or another type of criteria, it is to be emphasized that our orientation was to detect a proximal, "static" criterion, with a general, multidimensional character, but with possibilities for being changed into a unidimensional one, according to the concrete conditions offered by the research. To this effect, the grades obtained by the students during the schooling period in knowledge tests, project and final examination, as well as a rating scale were used.

Choice and validity of psychological tests. The test battery we chose is the Computer Programmer Aptitude Battery (CPAB), worked out by J. F. Palormo (1967). The Battery consists of five subtests: Verbal Meaning (VM), Reasoning (R), Letter Series (LS), Number Ability (NA) and Diagraming (D). The Domino 48/70 (1961) was also added, and the Domino 48/70 and Abstract Reasoning (AR) (subtest of the DAT battery), tests for junior-programmers.

A supplementary item analysis study was initiated for the VM subtest, the former being reshaped in accordance with the results obtained.

The factorial analysis of the test battery revealed the existence

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of two factors which cover 55% and 15% respectively, of the variance. The former corresponds to a general factor, analogous to Spearman's "g" factor, named Intellectual potential or efficiency in analysis-programming; the latter is a bipolar factor, verbal reasoning - serial -algorithmic reasoning.

The set of subjects which formed the object of our validation studies consisted of participants in the post-graduate and high -scool-graduate course in data processing. The psychometric characteristics are mentioned in table 1.

In the validation of predictors used for psychological selection, attention was given to the working out of an instrument whose predictions are as stable as possible despite the lapse of time, and which does not easily alter its characteristics. To this effect, the validation of the test battery used for the selection of analyst-programmers included four successive cross-validations, corresponding to a similar number of post-graduate courses that were investigated. Table 2 is a synthesis of the prognostic value of the psychological tests. The analysis of the results yielded by the four cross-validations enables us to draw the conclusion that the VM and NA subtests have a smaller reliability as compared with the rest of the tests. The overall validity of the battery, estimated by the multiple correlation coefficient, ranges from .540 to .692. For junior-programmers, the overall validity of the test battery was .784.

The gain achieved by using the psychological tests is 20% for analyst-programmers and 30% for junior-programmers. It is advisable that only those should be admited to courses who have 70% (stanine 7) and respectively 79% success chances (stanine 5) (Pitariu, 1977; Pitariu, 1978).

PSYCHOLOGICAL SELECTION AND TRAINING OF CARD-PUNCH OPERATORS

There have been attempts at validating some tests of psychological selection but they were scanty and, what is more, they had in view various types of card-punch, that is, a diverse relationship between man and machine. Under such circumstances, the elaboration of an adequate selection and training system, starting from a work place supplied with up-to-date outfit and manifold tasks is the object that has underlain the research in question.

Psychological analysis of the profession. One of the first aspects to have been considered as a starting point of the psychological analysis of the work was to ascertain the specific errors made in the punching activity. Lahy and Korngold-Pacaud (1936) distinguish three categories of errors: gaperrors - considered as most common, punch

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Table 1

Psychometric and criteria performance of the analyst-programmer and junior-programmer groups*

Variables	Analyst-programmers										Junior-programmers (N = 69)	
	Group I (N = 40)		Group 2 (N = 47)		Group 3 (N = 64)		Group 4 (N = 57)		Total (N = 224)			
	X̄	SD	X̄	SD	X̄	SD	X̄	SD	X̄	SD	X̄	SD
Age	27.90	3.52	28.29	4.74	28.84	5.65	28.30	5.43	27.78	4.62	28.00	6.71
CPAB - VM	18.89	7.27	14.47	5.99	14.83	5.26	14.70	6.14	15.15	6.26	10.07	4.74
CPAB - R	10.00	3.39	11.68	5.00	12.29	4.38	12.00	4.48	11.45	4.43	6.45	3.48
CPAB - LS	7.35	3.68	9.06	4.97	10.23	3.86	9.53	4.28	9.14	4.40	6.80	3.45
CPAB - NA	12.07	4.08	13.47	4.75	12.70	4.34	13.77	4.82	12.84	4.91	8.87	3.35
CPAB - D	15.95	6.67	16.94	9.08	16.66	7.57	16.86	8.66	16.32	8.02	8.69	5.84
Domino 48/70	27.93	6.01	28.55	6.91	28.06	5.23	27.25	5.12	27.90	5.71	24.28	6.76
DAT - Abstr. reas.	-	-	-	-	-	-	-	-	-	-	-	-
Criteria	53.73	20.56	48.77	17.30	3.03	1.10	6.65	1.55	3.09	1.16	34.29	8.27
											3.01	1.08

* In group 1 & 2, the criterion consisted of the overall score of the appraisal card, in group 3 of forced-choice rating, and in group 4, of combining the grades obtained in the course modules. For the whole group, the criterion consisted in the transformation of the other criteria into quotas disposed on a scale ranging from 1 to 5.

Table 2

Correlations (r) of test performances with success in data processing courses and the corrections (R) have in view the selection effect

Test	Group 1 (N = 40)		Group 2 (N = 47)		Group 3 (N = 64)		Group 4 (N = 57)		Total (N = 224)		Junior - programmers (N = 69)	
	r	R	r	R	r	R	r	R	r	R	r	R
CPAB - VM	.080	.080	.447***	.465***	.075	.085	.260*	.260*	.171**	.165**	.475***	.462***
CPAB - R	.455***	.568***	.487***	.487***	.408***	.420***	.295**	.295**	.327***	.330***	.449***	.394***
CPAB - LS	.460***	.547***	.220	.220	.301**	.330***	.369***	.388***	.218***	.223***	.282***	.287***
CPAB - NA	.189	.207	.346**	.346**	.391***	.407***	.186	.186	.215**	.215**	.286***	.286***
CPAB - D	.295**	.689***	.526***	.526***	.351***	.385***	.271**	.271**	.379***	.394***	.349***	.349***
Domino 48/70	.503***	.578***	.344**	.358***	.339***	.385***	.259*	.275*	.276***	.335***	.494***	.562***
DAT-Abstr. reasoning	-	-	-	-	-	-	-	-	-	-	.513***	.545***

* p = .05; ** p = .02 ; *** p = .01

errors, reading errors, i.e. transposition of figures (figures wrongly remembered; incorrect reading owing to the document). Durey (1960) has emphasized five error types: reading, reversal, double punching, omission and shifting of fingers in different directions. A sample where an alphanumerical material was used, enabled Kirchner and Banas (1961) to discover four main error types: spatial - 46.7% (pressing an adjacent key); perceptual - 24.9% (punching an "R" instead a "P"); reversal - 3.2% (punching a "25" instead a "52" - the digits being reversed); sequential - 25.2% (the operator became one column behind or one ahead with the result that a whole sequence of data was punched into the wrong column). In another research, Kirchner (1966) regroups errors in two types: perceptual - 56.4%; and spatial - 43.6% (r=.72). A work sample which we administered to professional operators revealed the following error types: perceptual errors (wrong reading of the source document) - 53.08%; sequential and reversal errors - 13.94%; and errors of operation (pressing of an adjacent key, wrong operation of ALPHANUMERIC key) - 32.98% (Pitariu, 1976).

The analysis of punching errors points to their location in the perceptive motor-speed and attention fields. Extra details can be obtained only by an analytic study of the operations carried out in the process of work.

A synthesis of the psychological work analysis data hads to the conclusion that the persons suitable for a key-punch profession should be young high-school graduates with or without a diploma, between the age of 18 and 25, endowed with an average intelligence, capable of resisting to effort and monotony as well as of enduring concentrate attention, possesing a good emotional stability. Persons having a good capacity of motor learning, hand coordination and finger dexterity will be prefered (persons with synkinesis cannot practice this profession, ncr those with anatomopathologic distortions of hands or spine). Persons conscientious in accomplishing work tasks, receptive to oral or written instructions, who easily accept supervision are also to be preferred.

Validation of test battery for key-punch operators. A number of ten psychologic tests were selected at first, from among which five have been retained as significant: Test of unremitting attention (UA) (Ricossay, 1960), Tapping (T), Test of distributive attention (DA) (Bontilă, 1971), Test of simple arithmetic abilities (AA) and Domino 48 (D 48) (1961). The factor analysis of tests reveals three factors: I - capacity of effort, attention concentration in the conditions of an intense activity (explained 37.65% of the variance); II - a factor of perceptual structuring, opposed to that of finger dexterity (ex-

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plained 23.38% of the variance); III - is a psychomotor factor (explained 18.93% of the variance).

The concurrent validity action which was initiated had in view a group of 50 key-punch operators between 20-25 ages. In order to ascertain the validity of tests, we have considered that a relevant criterion, fairly complete and capable of discriminating the operators from one another, can be set up by combining professional succes as reflected by the punching speed index and accuracy index, with estimations given by immediate supervisors. Consequently, a rating scale ranging from 1 to 10 was worked out. Dependent upon these elements an overall criterion was established which materialized in an arithmetical mean of the marks. Psychometrical performance and validity coefficients are ilustrated in table 3.

Table 3

Results of concurrent validity study

(N = 50)

Tests	Mean	S.D.	r	R corrected
Test of unremitting attention:				
- rythm imposed Slow+Fact	87.50	10.17	.441	.787
- rythm imposed Fast	64.08	12.38	.355	.657
Tapping:				
- first pair of fingers (T1)	53.35	9.31	.272	.254
- second pair of fingers (T2)	52.15	8.03	.229	.241
Test of distributive attention	60.81	14.24	.394	.394
Test of arithmetic abilities	271.52	69.77	.249	.272
Domino 48	20.27	6.33	.231	.234
$R_{1(2345678)}$			.645	
Regression equation: $X = 40(UA_{s+f}) + 7(UA_f) + 15(T_2) + 21(T_1) + 18(DA) + AA + 22(D48) - 4748$				

The test battery used for selecting key-punch operators has a multiple correlation coefficient of .645. In practice, the subject considered "admitted" are those whose overall score is over stanine 5, their average success chance being 85%.

Professional training of key-punch operators. Professional training of key-punch operators follows the psychological selection system in logical sequence. In this connection, the operators selected have attended a course consisting of three modules: (a) machine operation technique that generates the data support compatibles with the computer; (b) initiation in automatic data processing; (c) development of key-punching skils.

In so far as development of key-punching skils is concerned, two directions of action have been taken: the operators have practised

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key handling for a week and then the training went on with formative character exercises of the type recommended by Keys and Powell (1970), parallel to the integration of operators within routine production activity. Performance skils have been evaluated by testing at the end of each week.

Figure 1 illustrates the operators' average performance dynamics. Between the first and the last performance evaluation test we obtained an efficiency increase of 43% (t=4.21; p <.01), achieving a final performance of 8 080-11 040 keystrokes per hour. Errors have lowered by 3.72% (t=3.76; p <.01). (Pitariu, 1980).

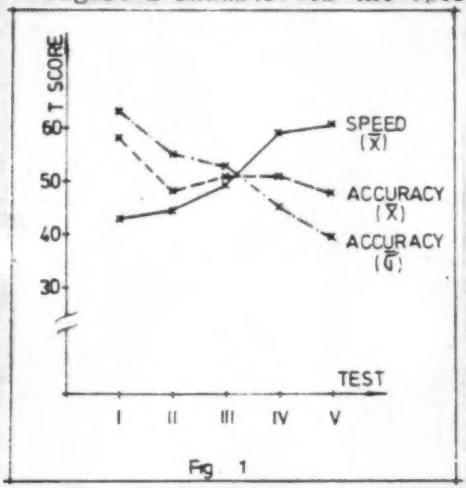

Fig 1

The strategy of selection and professional training of key-punch operators is illustrated by the flow chart in Figure 2.

SELECTION OF COMPUTER OPERATORS

The detailed analysis of the computers operator's activity led us to the conclusion that supervising of the system operation stands for 26.46% of his entire activity and 25.94% of his activity concerns work organization.

In semblance, what the operator does, refers to a sequence of perceptive-motor actions. In fact his perceptive-motor actions are the consequence of a complex decisional process that implies the participation of various elements furnished both by the specificity of the work to be performed and by the possibilities of the computer. Without exhausting the ability complex required for a computer operator, we mention some psycho-physiological traits and attributes that can characterize an operator and stood at the basis of a psychological test battery work out for selection purposes: integrity of the visual and auditory analysers, accuracy and surety of eye-hand coordination and of motric responses. The operator is characterized by a keen sense of observation and a short response time in decision making, marked by a tensional context associated by frequent conflictual situations generated by the system functioning. From an intellectual point of view, the operator's psychical qualities are similar to those of the programmer's (clarity and flexibility of thinking, logical planning of actions, fine analytical-synthetical capacity etc.).

Validation of the psychological tests used in selection is a difficult task owing to the restricted number of operators (N=21, awerage

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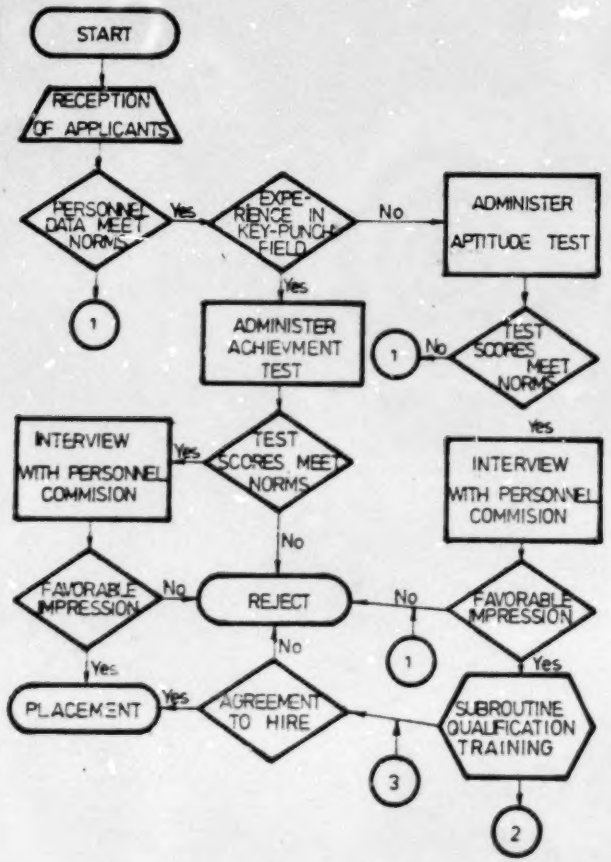

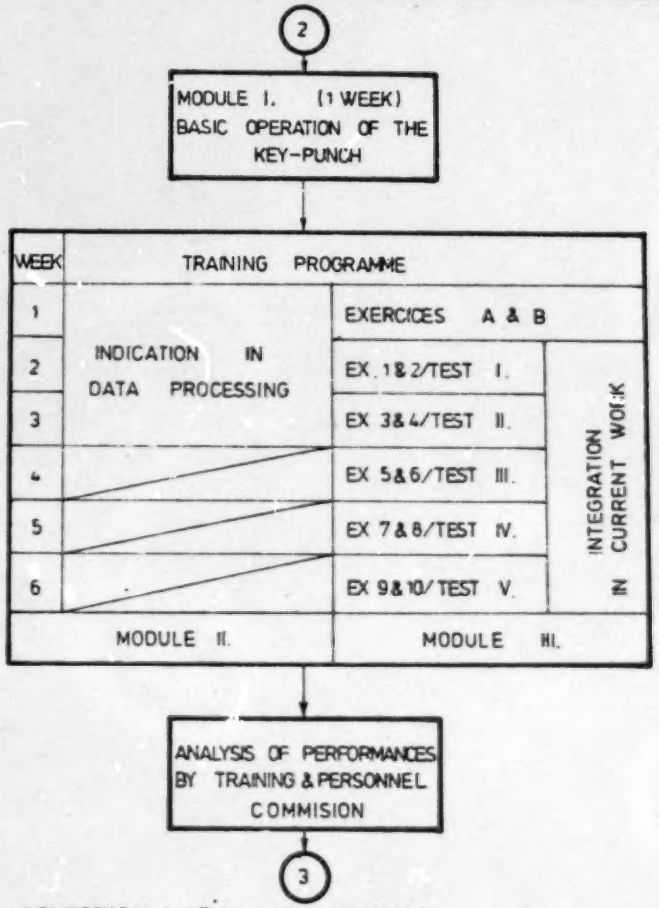

Fig. 2 FLOW CHART OF KEY-PUNCH PERSONNEL SELECTION & TRAINING PROCESS

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age: 25.6 years). We only resorted to psychological tests that were administered individually so as to enable the clinical analysis of the data obtained. Thus, the psychometric score has had a secondary part, the behavior analysis being taken as a selection basis (thinking strategy, logical solutioning of some problems of non-verbal character, emotional equilibrium etc.).

Of the tests selected, the following have been retained as having a significant validation (the criterion stood in ordering the operators by rank): B-20 (r=.505); B-101 (r=.445); SNB - duration of errors (r=-.470) (tests worked out by Prof. Bonnardel); and Finger dexterity test (test of the GATB) (r=.460). The overall validity of the test battery is $R_{1(2345)} = .685$.

The employment procedure consists in the following steps:

- Analysis of personnel data
- Knowledge test for experienced applicants
- Psychological examination
- Interview with examination commission.

Each step is a rejecting as to its nature.

The "admitted"/"rejected" decision in the psychological exam is taken on the basis of the qualitative analysis of profile: thinking strategy and rapidity, the logic of non-verbal problem solving, emotional balance etc.

CONCLUSIONS

The investigation undertaken answered to a major problem that confronts the national economy of Romania, namely the problem of providing efficient personnel for informatics. We must here specify that in our conception the psychological selection examination is but a subroutine of a vast programme of professional training. The part it acts is prominent in the field we deal with as it represents the first step in administering the human factor, a step where the risk of making an erroneous prediction must be diminished at its minimum.

The psychological exam acquires various valences depending on the objective aimed. In the case of post-university and high-school-graduate courses for analyst/junior - programmers' training, the objective of the selection exam stood in eliminating the persons unconsistent with this job and in organizing homogeneous groups capable of facing the exactingness of an intensive course. Of course, when hiring a trained personnel an analyst-programmer or junior-programmer jobs, the ability examination is of much lower importance as the psychological exam is centered upon other coordinates and is correlated with a professional one.

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Concerning to key-punch operators and computer operators the psychological examination plays a prevailing part, the psychological selection bring imposed by the fact that the professional training is carried out on the job. In case of hiring experimented personnel, psychological exam is still topical, with the emphasis shifting in this context upon the candidates' capacities of socio-professional integration in the work team.

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